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Fall and winter ecology of the Shiras moose (Alces alces shirasi) in the Rock Creek drainage Granite County Montana

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THE FALL AND WINTER ECOLOGY OF THE SHIRAS MOOSE, (ALCES ALCES SHIRASI), IN THE ROCK CREEK DRAINAGE, GRANITE COUNTY, MONTANA

by

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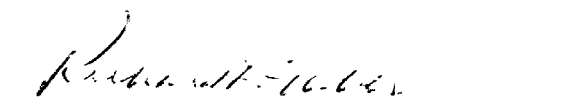

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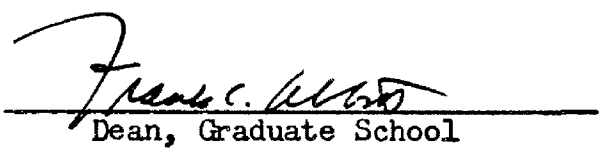

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INTRODUCTION

Between 1908 and 1910 George Shiras, III, discovered that the moose in Yellowstone was an undescribed subspecies. Nelson (1914) described this animal as Alces americanus shirasi. In 1952, Petersen reviewed the living representatives of the genus Alces and concluded that all of the living forms should be classified in a single species, Alces alces, which is widely distributed in northern Europe and Asia as well as North America. The subspecies being considered here thereby became Alces alces shirasi.

The main geographic range of the Shiras moose is western Wyoming, eastern and northern Idaho, and western Montana northward into southwestern Alberta and southeastern British Columbia. There is an occasional record of this moose in extreme northeastern Utah (Petersen, 1955). Between 1860 and 1866 Milton Estes shot a moose in Estes Park, Colorado. That and remains of a moose found in South Park, Colorado in 1871 establish the southern limit of the Shiras moose (Bailey, 1940, 1944).

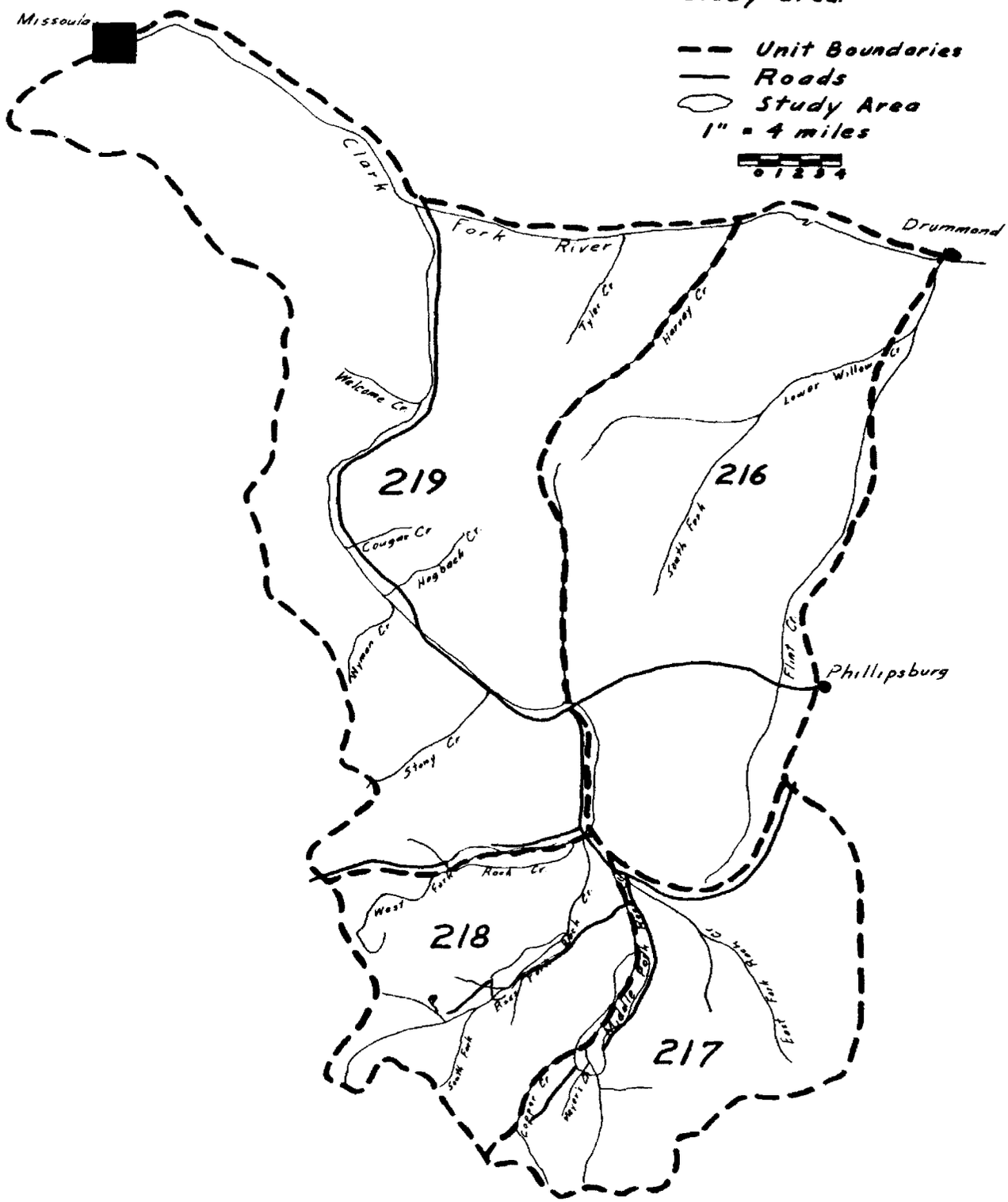
The Shiras moose differs from other North American subspecies in that it is medium sized, with a relatively wide nasal aperture, and a relatively pale coloration of pelage along the back (Petersen, 1955).

In the early 1900's there were few moose in the Rock Creek area of western Montana. Protective legislation, more stringent law enforcement and habitat changes caused an increase in the population. Since 1947 moose have been harvested on a limited basis in the Rock Creek area (Rognrud, 1956). The present study is the first intensive investigation of moose in this area. Information gathered in other areas of Montana, Wyoming, and Idaho (McDowell and Moy, 1942; Basset, 1951; Rudersdorf, 1952; McMillan, 1954; Harry, 1957 and Knowlton, 1960) have been only partially applicable to moose management in the Rock Creek drainage, principally because of habitat differences.

This study was conducted from September 1958 to April 1960. From the fall of 1958 to December of 1959 the study was conducted on a part-time basis. It was carried on full time from January 13, 1960 to April 23, 1960.

Appraisal of the willow flats and the distribution and population structure of moose on the winter range were emphasized in an effort to gain a clear picture of winter range relations. This information was supplemented with studies of winter activity, daily movements, and food habits.

Figure 1 Map of Fish & Game Department management units in relation to study area.

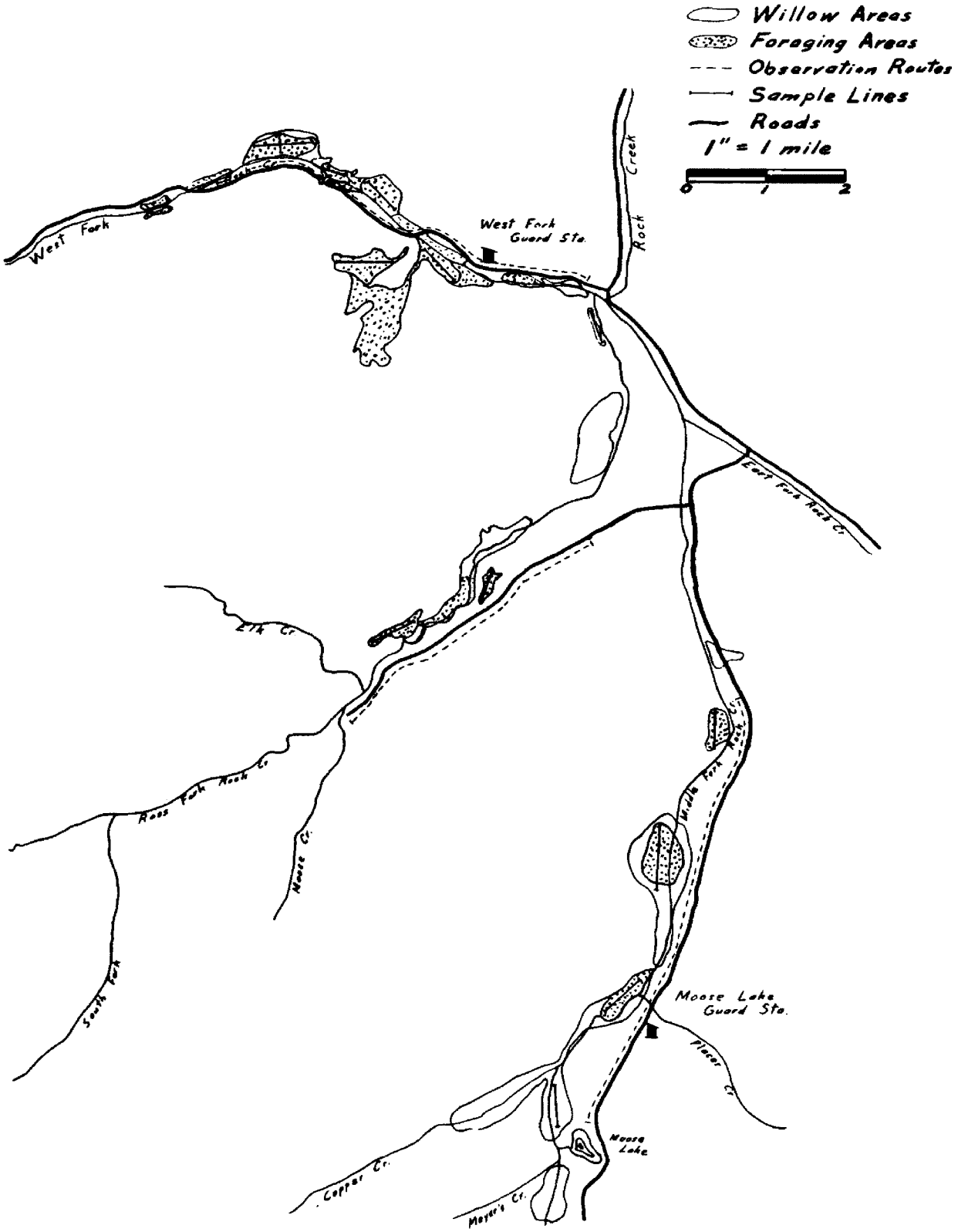


STUDY AREA

Description. Rock Creek drainage, the larger study area, lies in the Lolo National Forest and the Deer Lodge National Forest in Granite County, Montana. (See Fig. 1) The data on reproduction and population composition pertain to this area. The winter investigation was confined to the portion of the study area along the West Fork, Middle Fork and Ross Fork of Rock Creek, in the Deer Lodge National Forest. (See Fig. 2)

The winter study area covers about twelve and one-half linear stream miles and is from 200 to 1,000 yards in width. Its elevation ranges from 5,200 feet to 5,900 feet above sea level. The plant cover is riparian, with willow (Salix discolor, S. commutata, S. lemonii) the dominant browse species. Other shrubs and trees present are red-osier dogwood (Cornus stolonifera), a wild rose (Rosa spp.), bog birch (Betula fontinalis), honeysuckle (Lonicera spp.) quaking aspen (Populus tremuloides), ninebark (Physocarpus malvaceus) and buffalo berry (Shepherdia canadensis). Adjacent coniferous cover is composed of Douglas fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa), lodgepole pine (Pinus contorta), Engelmann spruce (Picea engelmanni) and western larch (Larix occidentalis). Herbaceous plants include

Figure 2. Map of study area showing distribution of willows, foraging areas, observation routes, & location of sample lines.



various grasses, sedges and forbs; these are covered by snow during the time the moose are on the winter range.

The soils of the area are derived from a parent material of limestone. The area lies within a belt of 15.5 inches of annual precipitation and the prevailing winds are from the southwest (Kirkwood, 1922). The nearest weather station is in Philipsburg, which is about 15 miles from the study area. The elevation of this weather station is 5,275 feet above sea level or approximately the same as the study area. Records at this station show that the average annual snowfall is 42.2 inches, with most of it falling between November and April. January is the coldest month with a mean of 16 degrees F. Very cold temperatures are not uncommon. During the time of the study a low of 42 degrees below zero was recorded by the writer. The warmest month of the year is July with a mean of 63 degrees (Kirkwood, 1922). A thirty-five year average annual precipitation for the Philipsburg station is 14.75 inches (Hambridge, 1941).

Logging. Currently, logging in the area is limited but access roads are being surveyed on the West Fork of Rock Creek. On the Middle Fork of Rock Creek there is a company cutting Douglas fir and lodgepole pine on the slopes south of the Moose Lake Guard Station. In Granite County, Douglas fir constitutes the bulk of the timber cut; it constitutes 8 million board feet of the 9.25 million total. Lodgepole

pine, larch and ponderosa pine, in that order, make up the remainder.

History. In the 1860's the area was alive with prospectors. The hub of the activity was located in the Flint Creek Valley. In 1865, Philipsburg was settled and reached its peak by 1893 after which it was practically deserted (Anon., 1960-a). It is now a town of about 1200 inhabitants.

Livestock grazing has been important in Granite County since George Metcalf brought the first cattle into the area in 1857. Horses, cattle and sheep have since used the range excessively. Overgrazing is obvious even to the layman. Both gully and sheet erosion can be found extensively (Anon., 1960-b). Climax grass species are bluebunch wheatgrass (Agropyron spicatum), Idaho fescue (Festuca idahoensis) and rough fescue (Festuca scabrella). Presently much of the grazing area is covered with timber oatgrass (Danthonia intermedia), shrubby cinquefoil (Potentilla fruticosa) and prairie junegrass (Kolaria cristata) which in this area indicates heavy past use. However, cattle number fewer on the Deer Lodge National Forest now than they did in 1920.

An even larger reduction has occurred in sheep numbers. Fallen beetle-killed lodgepole pine has made much of the area inaccessible to grazing. There has also been a general area-wide decline in sheep raising.

Interviews with several persons who settled in the area as early as 1905 indicate that moose were either absent

or occurred rarely in the Rock Creek area at that time. Mr. Wyman, who lived on main Rock Creek since the early 1900's, said that he began to see moose frequently about 1940 and that now moose are a common sight around his ranch. Sidney E. Lawson, who was working on the east side of the Bitterroot National Forest from 1907 to 1909, said that while working along the Rock Creek-Bitterroot divide and when he fished in Rock Creek, he neither saw nor heard of anyone seeing moose in the area at that time. The caretaker at Moose Lake stated that he saw moose only occasionally when he was prospecting on the Middle Fork of Rock Creek in 1908. However, he also stated that moose have never been abundant in that area and that even now he sees very few moose.

The general trend of moose populations in Montana, Wyoming, and Idaho has been that during the early 1900's there were few moose and that a steady increase occurred until about 1949 (Hatter, 1949). It is the opinion of the Fish and Game biologists in western Montana that since 1950 the population has not increased appreciably.

Present land use. Currently, 30.8% of Granite County is in farms and ranches. The total farm and ranch land is 341,000 acres, of which 299,000 acres are in pasture. Most private land in the study area is used as pasture or range land for cattle. The average price per acre of land in Granite County was $23.37 in 1958. Elsewhere in the state, average prices ranged from $8.22 to $99.51 per acre (Anon.,

1960-a).

Competition for range. The moose winter range in the study area receives limited use by cattle and horses in the fall and winter. There are also a very few elk and deer that use the willow of the study area in the winter.

Just where the moose go in the spring is not known precisely, but it appears that in early spring they move from the willow bottoms to the adjacent timbered foothills, the "intermediate range." Then, as the snow melts on the higher ridges, they go to these elevations for the succulent new growth of vegetation. Elk (Cervus Canadensis) and deer (Odocoileus hemionus) are also found on these higher areas at this time.

METHODS OF THE STUDY

Moose collection kits. In order to obtain information about reproduction, sex and age composition and food habits it was necessary to collect data from harvested animals. Since the moose in the area are harvested on a permit basis it was possible to know in advance who the hunters would be. These hunters were contacted prior to the opening of the season and asked to collect samples from the carcass of each animal killed. For this collection a kit consisting of a cardboard carrying carton which held two two-quart mason jars was sent to each hunter. One jar was partially filled with formalin for a rumen sample and the other contained Bouin's solution for the reproductive tract of females. A questionnaire, a set of instructions, and a return post card completed the contents of the kit. In the questionnaire the hunter was requested to provide information pertaining to date, sex and location of kill. These kits were sent to 54 hunters; of these, 27 returned usable material. Only 6 of 33 successful hunters failed to return the kits. The use of these kits, which cost approximately $.55 to produce and mail, appears to be a satisfactory method of obtaining information from animals that are harvested on a permit basis.

Winter observations. During the winter portion of the study, routes along one side of the willow flats, the principal moose foraging area at this season, were traversed twice daily, once in the morning and once in the evening. (Example: West Fork in the morning, Middle Fork in the evening and Ross Fork the following morning). Along these routes, locations of tracks crossing the road were recorded and animals observed were recorded as to location, sex, age and activity. Daily weather conditions and snow conditions were recorded at established points. An 8X35 mm. binocular was used in the observation of moose.

Twenty-two moose were backtracked from foraging areas to their bedding sites to furnish data pertaining to daily activity.

Range studies. By observation of areas located along the routes described above it was possible to determine which areas were actually being used by moose for foraging. Potential feeding areas were then designated as either forage or non-forage areas. A modification of Cole's (1958) closest-plant technique of browse sampling was used to sample the willow stands in various areas. Forage and non-forage areas were both sampled for comparative purposes. The point of origin for the sample line was established by throwing a clip board into the selected area. A compass line was projected through the area, along which a random number of steps ranging from 1 to 7 were taken to establish each sampling

point. The closest willow within a 180 degree zone in front of each sampling point was selected. On this plant various measurements were taken. The distance from each sampling point to the periphery of the selected willow was measured for a density index figure. Each willow was classified according to form class, per cent leader use, species, decadence and age.

Form classes were of 8 categories: 1. all available, little or no hedging; 2. all available, moderately hedged; 3. all available, severely hedged; 4. partly available, little or no hedging; 5. partly available, moderately hedged; 6. partly available, severely hedged; 7. unavailable; 8. dead. Estimation of leader use was made in the following manner: 0 = no use, 5 = 1-10 %, 25 = 10-40 %, 50 = 40-60 %, 70 = 60-80 %, 90 = 80-100 %.

The plant was considered decadent if 25 per cent or more of the crown was dead. Age was determined by counting the annual rings of the largest stem in the cluster. A jackknife or hatchet was used on the smaller stems and an increment borer was used on the larger stems.

This system was used to cover large areas in a minimum amount of time. The number of observations in each area varied with the length of the lines, which was determined by the size of the area; thus the total number of observations in each drainage was different. There were six areas sampled

in the West Fork, four in the Middle Fork and three in the Ross Fork.

Food habits. Examinations of feeding sites were made in an effort to establish preference of moose for plants that were available in the willow flats. A fresh moose trail was selected in a forage area and followed. Each freshly browsed leader was considered as an "instance of use." Distinction of recent and old browsed leaders was made possible by the color and freshness of the exposed wood. This method permitted distinction of leaders browsed within a period of several weeks. The aggregate percentage method (Martin, et. al., 1946) was used in the tabulation of these data.

Rumen analysis was done by personnel of the Montana Fish and Game Department Food Habits Laboratory in Bozeman, Montana. After the samples were collected in the field they were placed in two-quart jars with 10 per cent formalin solution. When the samples were ready for analysis, a moderately packed quart sample was washed over a 1/8 inch wire mesh screen, using a gentle spray of water from a hose. The residue was then manually separated into piles of like materials. After separation the items were identified by species, or, in a few cases, by family or genera, by comparison with herbarium specimens. For thoroughly masticated items, such as small pieces of barkless twigs, a small sample was used in estimating relative abundance of the various species. After separation and identification the items were damp

dried with paper towelling and measured volumetrically by water displacement to the nearest .1cc. in a graduated cylinder. Items measuring less than .1cc. were recorded as a trace. This method of analysis was worked out by Kenneth Greer, of the Montana Department of Fish and Game, who conducted the laboratory work on moose rumen samples.

Summer observations. During the summer of 1959, anglers, wardens and biologists who were in the Rock Creek area were asked to report the sex, age (if possible), location and time of any moose seen. The operators of the Montana Fish and Game Department creel census checking station located on lower Rock Creek recorded these data.

MOOSE OBSERVATIONS

Population estimates. Due to variation in pelage coloration and shape of dewlap or "bell" it was possible to distinguish many individual moose. During the winter portion of the study, moose were observed with binoculars and a sketch was made of any distinguishing characteristics. The pattern of the light-colored hair on the lower part of the leg as it joined the darker hair on the upper leg was especially helpful in identifying individuals. Dewlaps which had a characteristic shape, such as bifurcate, baggy or long and pendulous, when coupled with pelage coloration, made identification fairly positive. The grouping of individuals, such as cow with calf, cow with yearling or pair of bulls was also used as an aid to recognition of individuals.

A modification of the Lincoln index developed by Schnabel was one method used to estimate the number of moose using the study area (Kabat, et. al., 1953). Table I shows the estimated moose population based on calculations involving eleven recognizable moose. From observation of track locations and the dates they were seen, a second estimated number of moose was calculated. Both methods gave closely similar results. The Schnabel method indicates that 26 moose

Table 1. Population Estimates by Schnabel Method

Date	Total moose seen (S)	Marked moose available each day (M)	Repeat observ. (m)	MS	$\sum$MS	$\sum$m	P= $\frac{\sum MS}{\sum m}$
1-13	1	0	0	0	0	0	0
1-15	1	0	0	0	0	0	0
1-20	1	0	0	0	0	0	0
1-29	1	0	0	0	0	0	0
2-2	2	1	1	2	2	1	2
2-3	1	2	0	2	4	1	4
2-4	1	3	0	3	7	1	7
2-5	3	5	0	15	22	1	22
2-9	2	6	1	12	34	2	17
2-11	1	6	1	6	40	3	13
2-18	1	6	0	6	46	3	18
2-24	3	8	1	24	70	4	18
2-26	1	9	1	9	79	5	17
2-27	2	11	0	22	101	5	20
3-10	2	11	1	22	123	6	21
3-11	3	11	0	33	156	6	26

were using the winter study area and information from track observation indicated that there were 28 moose.

Population composition. From hunter kill, poached animals, and summer and winter observations, it was estimated that there were 42 per cent males, 43 per cent females and 15 per cent calves in the Rock Creek herd. These data are summarized in Table II. Yearlings were included with adults because hunters and fishermen, from whom some observations were obtained, were unable to distinguish yearlings from adults with accuracy. The data in Table II are obviously in error to some unknown extent because of differential vulnerability to hunting and the difficulty of observing young calves in the true proportion that they exist in the population. With regard to the first possibility, Pimlott (1959) found evidence that yearling moose in Newfoundland were perhaps 1.4 times as vulnerable to hunting as adults. Calves were also legal game in Newfoundland. There Pimlott thought that hunters tended to refrain from shooting calves, so that they appeared in the kill in smaller proportion than they appeared in the herd. The observations of Maliepaard (1962) suggest that if this is the case the bias is not great, since in his Saskatchewan study the cow-calf ratio in the kill was quite close to that in the herd after the hunting season. On the other hand, summer observations on cow-calf ratios are notoriously difficult to make with

accuracy; observers tend to miss young calves (Pimlott, 1953; Peterson, 1955; De Vos, 1956). The data in Table II, admittedly scanty, shows a higher percentage of calves in the kill than in the summer observation period; the respective cow (adult plus yearling): calf ratios are: summer, 100:28; hunting season (1958 and 1959), 100:38. The winter ratio is 100:50. These values tend to support the findings of other investigators that calves are overlooked in summer observations, and possibly are less vulnerable than other classes to hunting.

Age class composition. Age class designation of twenty jaws obtained from moose hunters, determined by tooth wear and tooth eruption (Peterson, 1955) are set forth in Table 3.

All that can be said concerning the data on age distribution in the kill (Table 3) is that it appears to reflect a moderate rather than heavy hunting pressure. Occasional winter kills of old animals could be expected in such a population.

Breeding season. The gestation period of moose is from 240 to 246 days (Peterson, 1955). Assuming that the breeding season begins the first of October, the calves would be born about the first of June, which is, in the study area, a favorable time for calving. At this time a variety of succulent vegetation becomes available and abundant.

Table 2. Observed Population Composition of Moose in Rock Creek Area

Method	Date	Males	Females	Calves
Harvest	1958	12	9	3
Summer obser.	1959	22	25	7
Harvest	1959	6	4	2
Winter obser.	1960	5	8	4
Total		45	46	16
%		42	43	15

Table 3. Age Class Composition as Determined by Twenty Lower Mandibles Collected from 1958 to 1960

	Age or Wear Classes[1]							
	Calves	I	II	III	IV	V	VI	VII	VIII
Number	6	3	3	4	0	1	1	1	0

[1]Method of Passmore, Peterson and Cringan in Peterson (1955).

According to Skuncke (1949) a variety of vegetation produces a well-balanced diet, which enriches milk production. Through natural selection animals that breed at a time which allows the young to be born at a favorable season are more apt to survive in that area. It is possible for the rut to vary locally to fit existing phenological conditions. Altmann (1959) found that in Wyoming the breeding season starts as early as the beginning of September and extends into late October and that there are rare cases of moose breeding in August and in December. Edwards and Ritcey (1956) state that 85 per cent of the pregnant moose in British Columbia were bred in a ten day period in late September.

In the present study, an old cow killed on September 29 had not ovulated, whereas a yearling cow taken on October 3 displayed a corpus luteum of pregnancy, and every cow killed thereafter until the last specimen, on January 2, was pregnant (see Table 4). Since yearlings in most ungulates tend to breed later than adults, and since some senile animals do not breed regularly, these observations could be interpreted to suggest a principal breeding season spanning the last two weeks of September and birth during late May. There are no field observations, however, either to support or weaken this hypothesis.

Productivity. Eight reproductive tracts were obtained from hunters during the study. Dates of kill ranged

Table 4. Summary of *Corpora Lutea* and Fetuses of Eight Reproductive Tracts Collected in Rock Creek Area

Coll. No.	Date	Age	*Corpora lutea*	Fetuses	Pigmented areas[1]
7	Sept. 29	8½+	0	0	9
9	Oct. 3	1½	1	0	0
4	Oct. 9	6½	2	0	8
8	Oct. 12	7½	1	0	4
32	Oct. 19	?	1	0	4
5	Dec. 5	3½	2	1	4
5A	Dec. 15	1½	1	0	0
16	Jan. 2	?	1	1	5

[1]Pigmented areas were blood clots and/or *corpora rubra*.

from September 29 to January 2.

The cycle for North American cervidae is presented here in order that the reader may more fully understand the interrelationships of ovulation and fertilization, and evidence concerning these that may be found in the ovaries. For wild cervids, the ovarian cycle was first studied by Cheatum (1949), who found that the sequence of events, and the ovarian structures paralleling them, closely resembled those found for sheep and goats (Danforth and Doisy, 1939). Briefly, in these animals there is a definite breeding season. The female who is sexually mature experiences ovarian activity during which one or more Graafian follicles enlarge and migrate to the surface of the ovary. She "comes in heat" or reaches that point in her estrus cycle where she is receptive to copulation. Whether or not she experiences copulation, the ripe Graafian follicles discharge their ova through rupture sites in the ovarian surface. The ruptured follicle fills with cells and increases in size; it is now called a corpus luteum. Ordinarily, in the wild, the female in heat is successfully bred and the ovum is fertilized and implanted on the uterine wall. If this occurs the corpus luteum continues to develop and maintains a large size (equal to perhaps one-third the total volume of the ovary) until the young is born. Then the corpus luteum of pregnancy begins to decline in size and deepen in color; it has then been called the

corpus rubrum or *corpus albicans*, or pigmented scar, of which the first seems the most accurate description.

In elk, there is often an ovulation the space of one estrus cycle later than the ovulation which results in pregnancy. This results in the formation of *corpora lutea* of secondary ovulation during pregnancy (Halazon and Buechner, 1956), which are characteristically smaller than primary *corpora lutea*.

This ovarian evidence of successful breeding is used in studies of wild cervid populations to cast light on the time of breeding, the proportion breeding in various age classes and the number of young produced per breeding female. This last is only possible where the relation between the number of ova shed and the number successfully fertilized, implanted and carried to full term has been determined. While the ovarian cycle of the moose has not been studied experimentally, the findings for other members of the deer family have been applied in a field study by Pimlott (1959). He distinguished between presumed primary and accessory (secondary) *corpora lutea* of pregnancy on the basis of size. Pimlott found a primary ovulation rate of 1.2 among yearling and older moose. In the present study, the ovulation rate, based upon *corpora lutea* of pregnancy in both ovaries, was found to be 1.1 for the same (yearling and older) age group.

An examination of corpora lutea in the eight sets of ovaries showed that seven of the cows had ovulated. Table 4 shows that the cow which had no corpora lutea was the earliest specimen collected. Both yearlings in this collection had ovulated. Pimlott (1959) found a yearling pregnancy rate of 66 per cent. He also stated that the nutritional level of cow moose in their first winter is probably the most important factor in the breeding of yearlings.

Net productivity is the per cent of calves in the fall population (Pimlott, 1959). Pimlott found that net productivity ranged from 20 to 25 per cent. In the present study the winter observations showed the proportion of calves in the sample to be 21 per cent.

There were no twin calves found in utero but two of the four adult cows examined had each shed two ova, and one cow on the Ross Fork had twins following her in the winter of 1960. Pimlott (1959) found that 35 of 142 adult cows, or about 25 per cent, had each shed two ova.

The evidence from the present study with regard to ovulation rate, breeding of yearlings, amount of twinning and winter calf-counts, is consistent with the hypothesis that the Rock Creek moose herd has a net productivity comparable to that of Newfoundland, or about 20-25 per cent per year (Pimlott, 1959).

Winter activity. Interviews with landowners of the area revealed that some individual moose inhabit the stream-

bottom willows the entire year. Petersen (1955) states that some moose, especially cows, calves and yearlings often spend the entire year in the lowlands. Moose started using the study area in greater numbers than previously about the first of January, 1960. Track counts showed that in one area on the West Fork there was movement back and forth at the upper limits of the wintering area until about the 25th of January; after that no tracks were seen in this upper area until about the 19th of March. Between these dates the moose were inhabiting the willows farther downstream. The most intensive use of the willows in the study area occurs between the first of January and the twentieth of March.

Activity appeared not to be affected by snow depths during the investigation in the study area. It takes well over 30 inches of snow to hamper moose (Petersen, 1955). Basset (1957) relates that moose were observed at 9,000 feet above sea level and in five or six feet of snow in Wyoming. Soil Conservation Service personnel at Philipsburg said that while on a snow survey in March, 1958 they saw a cow and calf in snow well over three feet deep.

During very stormy weather (snowing and very windy) moose movement in and out of the willows was curtailed. Following nights of such weather very few tracks could be found where moose had gone in or out of the willows. Following stormy nights no moose were observed feeding in the willows the next morning. Skuncke (1949) mentions that moose are

greatly influenced in their habits by certain weather conditions. Windy weather, which causes difficulty in hearing and picking up scent, restricts activity of moose. He states that during such times the moose will bed down in dense forest cover. In Ontario, De Vos (1958) says it is entirely possible that moose movements are more limited on days of high wind velocity.

It appeared that generally moose came into the willows or started feeding sometime after dark. The willow flats were observed for about an hour to an hour and a half before dark. Only once were moose observed moving about at this time on the study area. Most of the moose seen during the study were observed in the morning from daylight to one and one-half hours after daylight. The daily feeding cycle as reported by McMillan (1954) show a maximum at 7 to 9 a.m. and at 9 p.m. In Ontario, De Vos (1958) mentions that the evening cycle seems to be higher than the morning peak. He also states that during the middle of the day the ratio of bulls to cows seen was higher than in the early morning or in the evening.

In the present study the total number of tracks going into the willows on one side was greater than the number of tracks leading out the same side. There were 190 sets leading into the willows and 171 sets leading out. This might indicate one or both of two possibilities. Either the moose were bedding down in the willows or they were crossing the

willows and bedding down in the coniferous timber on the opposite side of the willows. Inasmuch as moose were seen bedded down in the willows during the day on only two occasions, it would appear that most of these moose were bedding down in the timber on the opposite side. McMillan (1954) says that there is no evidence that moose individuals use the same bedding sites day after day.

Twenty-three moose were back-tracked to their previous bed sites. All but four were bedded down between one-quarter and three-quarters of a mile from the foraging areas. The remainder were either in the foraging areas or more than three-quarters of a mile away. The majority of these bed sites were in areas dominated by Douglas fir and lodgepole pine (Table 5).

Table 5. Location of Beds, Habitat Type and Distance From Foraging Areas Determined by Backtracking and Observation

Date	Location	Distance from Foraging Areas in Miles	Habitat type
1-26	WF[1]	3/4	D.fir
1-26	WF	1/2	Willow-D.fir
2-9	WF	1/4	Willow
2-10	WF	1	D.fir-l.p.pine
2-10	WF	3/4	D.fir
2-2	RF[2]	1/2	D.fir
2-2	RF	1/2	L.p.pine
2-10	RF	1/2	D.fir
2-19	RF	1/4	L.p.pine
2-19	RF	3/4	D.fir-l.p.pine
2-4	MF[3]	1/2	D.fir
2-4	MF	1	D.fir
2-11	MF	3/4	D.fir
2-11	MF	1/2	D.fir
2-24	MF	0	Willow
2-25	MF	1/4	D.fir-l.p.pine
2-20	MF	1/4	D.fir
2-20	MF	1/2	D.fir
1-27	MF	1/4	D.fir
1-27	MF	1/4	D.fir
3-2	MF	0	Willow

[1]West Fork
[2]Ross Fork
[3]Middle Fork

WINTER RANGE APPRAISAL

Abundance. Aerial photographs obtained from the Soil Conservation Service were used to map the willow flats in the study area (Fig. 2). Present land practices are apparently compatible with the willow; however, in one location on the West Fork a small portion of willow has been uprooted and burned in an attempt to convert this acreage to pasture for cattle. This practice, if continued, could have considerable influence in diminishing the amount of moose habitat in this area.

Utilization. When measuring utilization the number of twigs or leaders browsed on each plant was estimated and converted to a per cent of the total number of leaders on the plant (Cole, 1958). This method was used as a measure of utilization. The assumption is that the per cent of leaders browsed is a function of browsing intensity; as utilization of forage increases so does the per cent of leaders used. Utilization was compared to: a density factor, age, availability, decadence and species of willow. Willow plants were grouped into three availability classes. "All available" plants were those which were from 2 to 7 feet tall, "partly available" plants which were over 7 feet tall but had browse available within the 2 to 7 feet range and

Table 6. Comparison of Density of Willow and Utilization by Moose in Thirteen Areas

Drainage	Location	Density factor	Average % Leader Use
West Fork	McKay	3.0	1 ± 1
	Richmyers	1.4	12 ± 4
	W. F. Station	1.5	14 ± 3
	Emerine Gulch	.9	16 ± 5
	Anaconda G.	.8	19 ± 4
	Saphire G.	1.1	35 ± 9
Ross Fork	Mouth	2.7	0 ± 0
	Christensen's	.9	17 ± 3
	Haystack	.9	21 ± 5
Middle Fork	Moose Lake Flat	1.0	[illegible] ± 3
	Squaw Creek	2.2	15 ± 4
	Moose Lake R. S.	1.0	18 ± 4
	Forest Boundary	.9	25 ± 7

"unavailable" plants were those which were over 7 feet tall and had no browse available.

A density factor was calculated by averaging the distances from random points to the nearest willow in each of 13 areas. Thus the density factor is inversely proportional to the density of the willow stand. Table 6 shows a comparison of utilization and density on these areas.

These data indicate that locations more densely covered with willow received greater use. Two locations, McKay in the West Fork and the mouth of Ross Fork, received the least amount of leader use and were less densely covered with willow than any of the other areas. In all three of the drainages, locations which had received the greatest amount of use were those which had dense stands of willow. On the other hand, Squaw Creek in the Middle Fork drainage did not have a dense stand of willow yet it received a substantial amount of leader use. This probably indicates that density is not the sole factor influencing utilization.

Many of the willows in the study area are resprouts and since it was not possible to determine the age of root crowns the data concerning age are applicable only to the above-ground parts. The dominant age group of willow shoots in all three of the drainages is between 4 and 9 years. Use generally corresponds with the age groups, the younger plants receiving proportionally more use than the older ones. About half of the six-year-old shoots (the predominant age)

received an average of 25 per cent use. The most heavily used shoots were between 4 and 9 years of age (Fig. 3). The willows on the West Fork (Fig. 4) and the Middle Fork (Fig. 5) exhibit this six-year-old predominance but on the Ross Fork (Fig. 6) the predominance is not so pronounced. Instead there is a tendency towards a higher percentage of older plants.

On all three of the drainages, the per cent of use on plants that were "all available" was greater than on plants that were "partly available" although the differences generally were not significant at the .05 level of probability when tested by Chi-square.(Table 7). These data imply that there is either a slight tendency for moose to browse on shorter plants or that there is a palatability difference between these form classes. McMillan (1953) found that 56 per cent of all grazing by moose in Yellowstone Park was on plants from 2 to 4 feet tall. In the present study, the "all available" willows were generally from 3 to 11 years old, while "partly available" willows were from 12 to 20 years old. The younger plants usually had more succulent leaders than the older plants.

As the willow grows older and the leaders escape browsing, the effects of apical dominance becomes more evident. The terminal shoot has an inhibitory effect upon the growth of lateral buds (Myer and Anderson, 1939). In the younger plants in which the terminal shoots or leaders are within

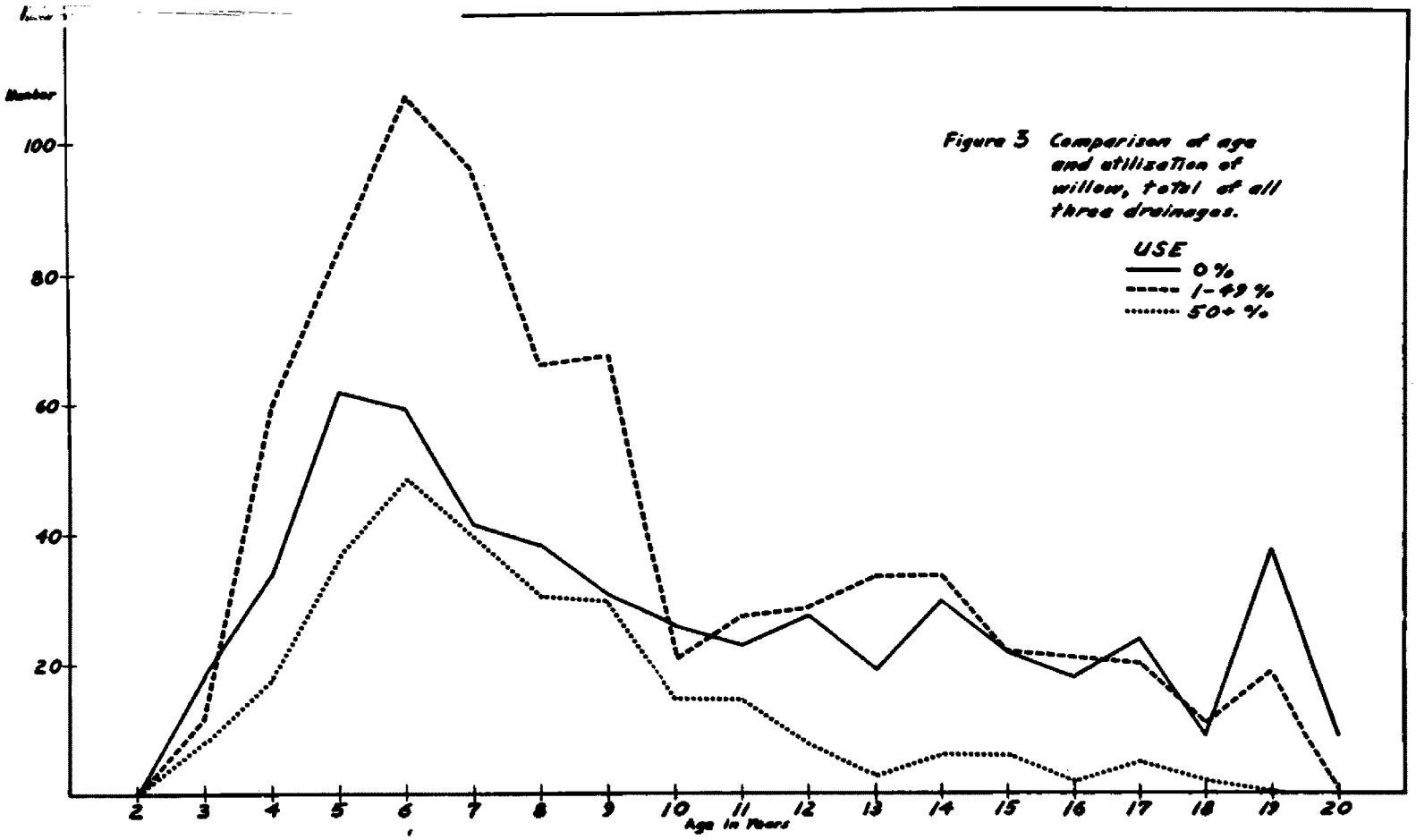


Figure 3 Comparison of age and utilization of willow, total of all three drainages.

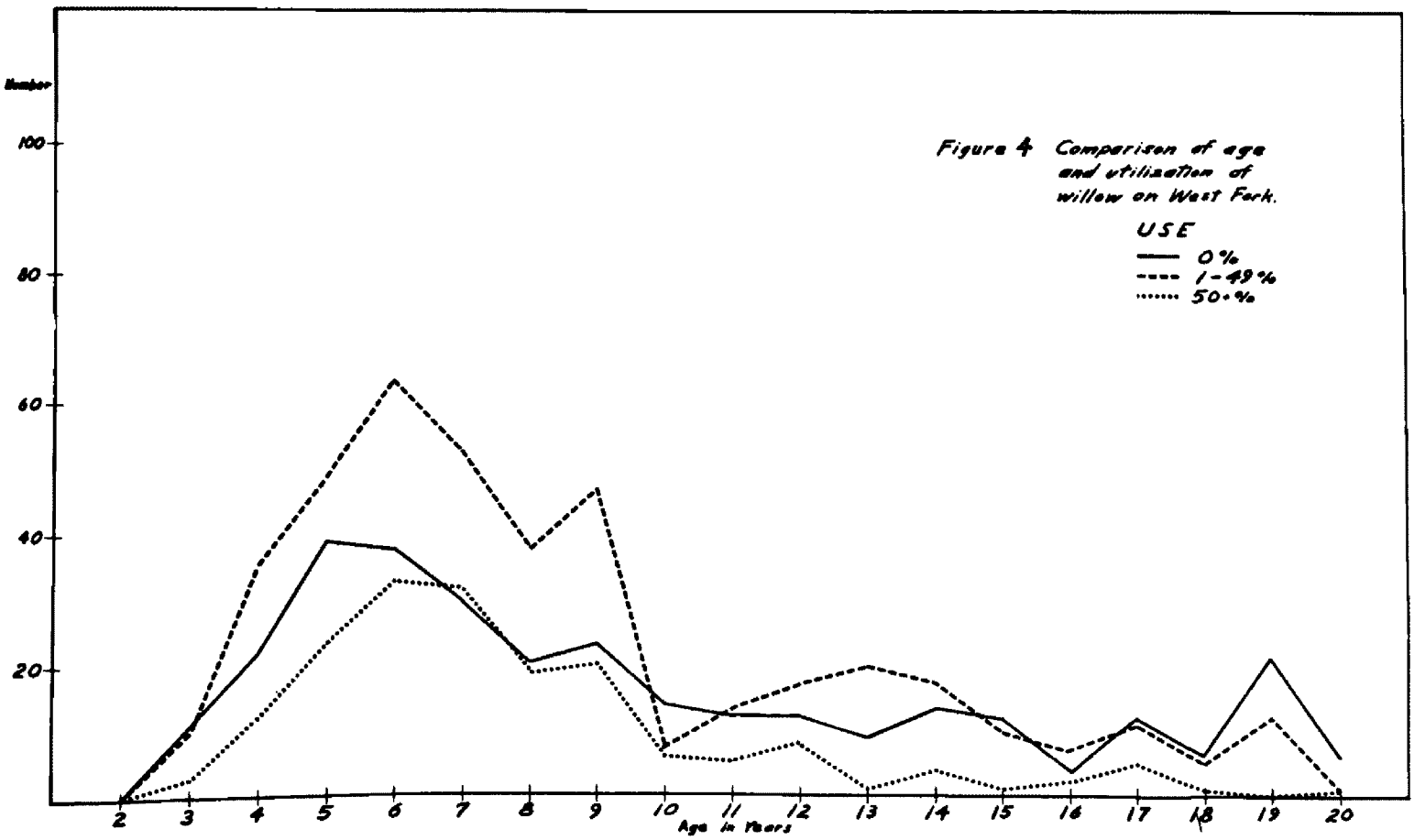


Figure 4 Comparison of age and utilization of willow on West Fork.

Table 7. Comparison of Availability Form Classes of Willow and Utilization by Moose

% Leader Use	All Available	Part Available
	West Fork	
0	30.7	43.3
5	29.7	33.6
25	17.2	13.4
50	13.5	7.4
70	6.6	1.4
90	2.3	0.9
	Middle Fork	
0	33.9	51.6
5	26.5	27.8
25	20.4	15.9
50	12.6	4.0
70	4.8	0.8
90	1.7	0
	Ross Fork	
0	31.9	44.4
5	28.7	32.2
25	16.5	15.6
50	16.5*	4.4*
70	5.3	2.2
90	1.1	1.1
	Total	
0	32.2	44.4 (±8.8)
5	28.3	31.2 (±2.7)
25	18.0	14.8 (±2.3)
50	14.2	5.3 (±5.4)
70	5.6	1.5 (±2.6)
90	2.4	0.7 (±0.7)

*significant at $P_{.05}$ level of probability

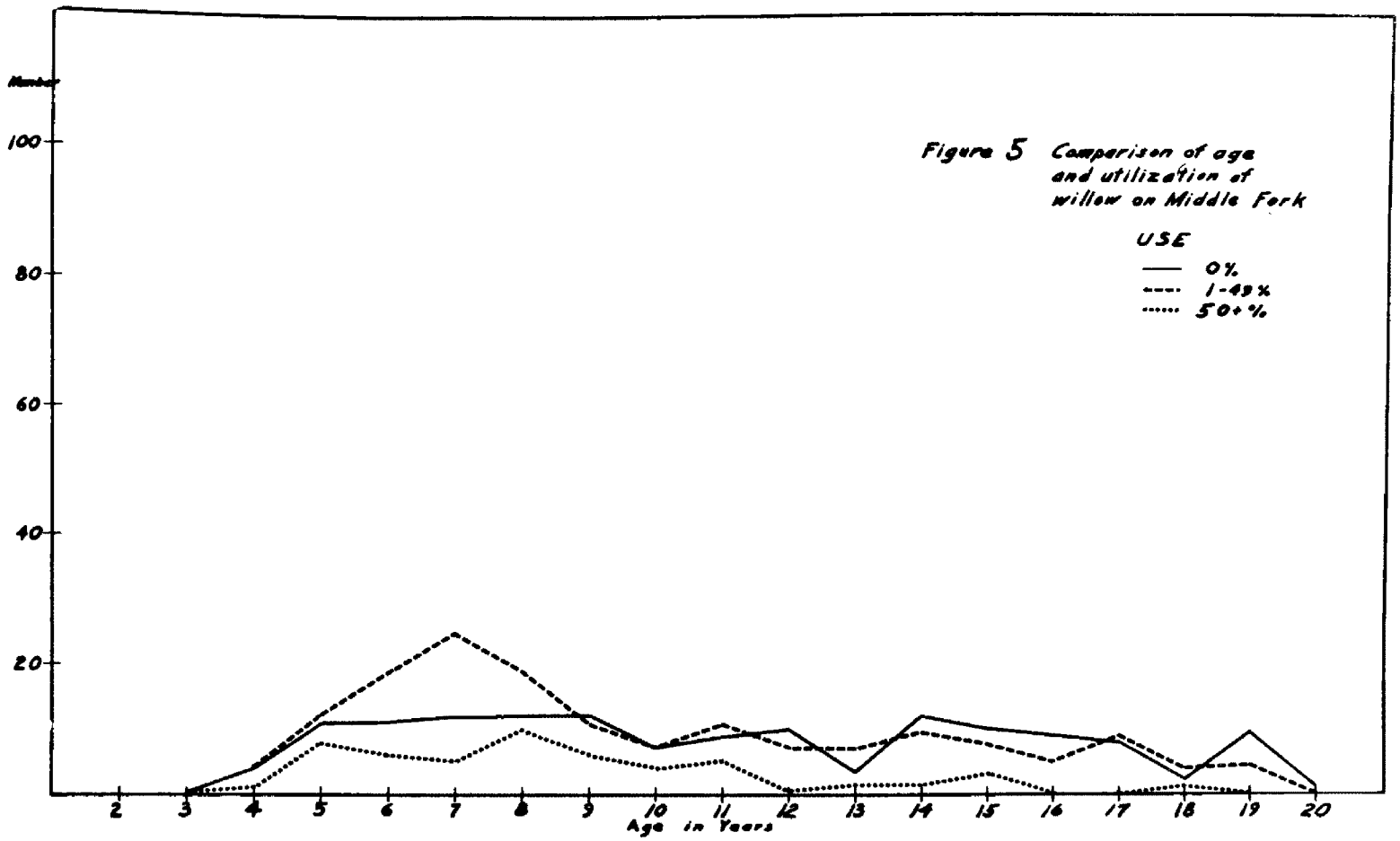


Figure 5 Comparison of age and utilization of willow on Middle Fork

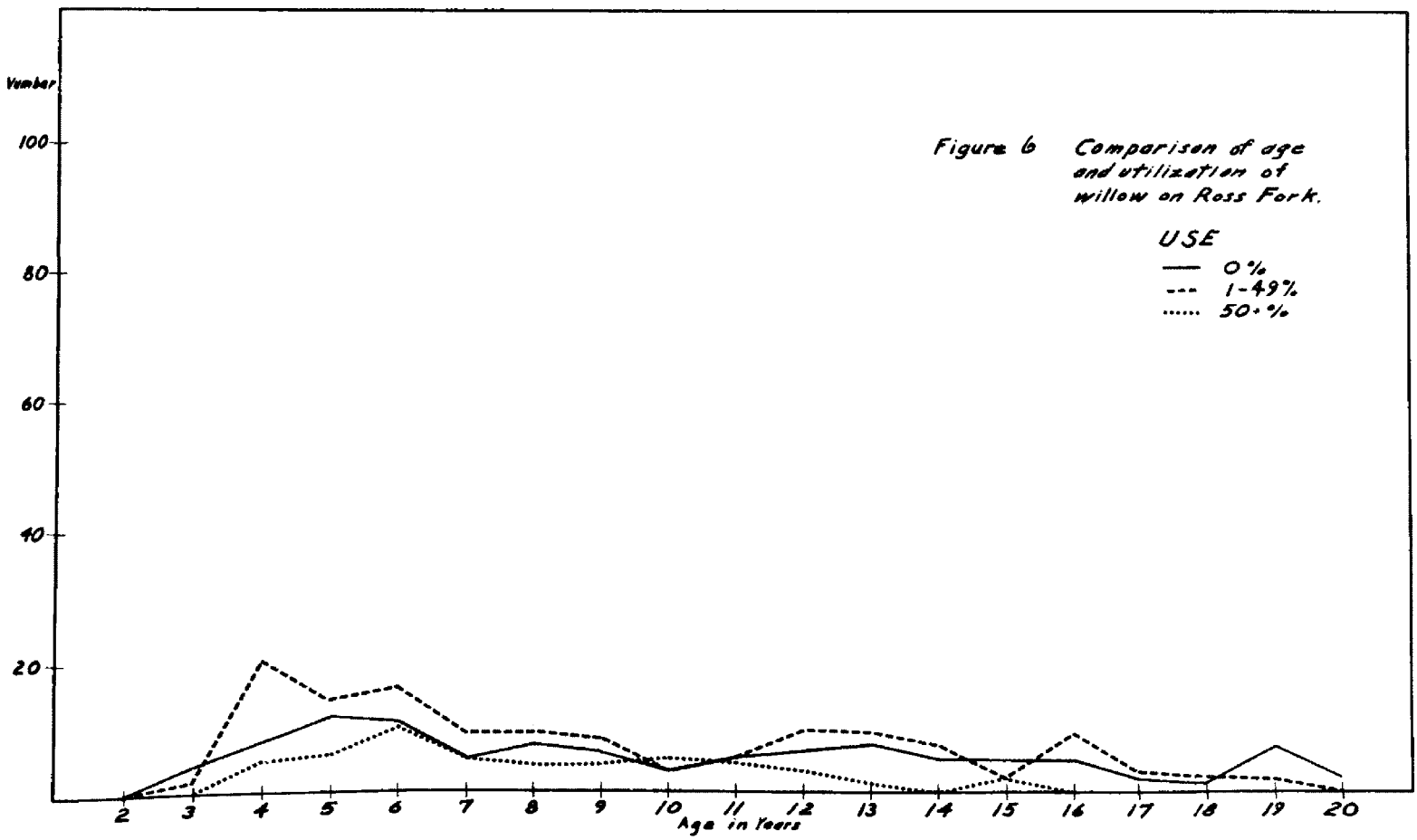


Figure 6 Comparison of age and utilization of willow on Ross Fork.

browsing reach of moose, the lateral buds are released from this dominance and the result is more lateral leader growth. The lateral leaders continue to grow until one establishes dominance. Thus browsing results in more fresh lateral growth and greater production of succulent forage.

Table 8, which compares degrees of decadence and utilization, shows that there is little difference between use of decadent and non-decadent plants. Young decadent willows that were resprouting furnished a considerable amount of succulent forage even though they were decadent. As the plant becomes older an increasing amount of forage central to the plant becomes inaccessible. Dead twigs and the diameter of the plant both tend to reduce the accessibility of the central leaders. However, in this study decadence had no significant effect on browsing and there appeared to be no difference in the amount of peripheral or central browsing by moose. These data are in agreement with McMillan (1953) who found that there was no significant difference in the amount of peripheral or central browsing of the copse. Incidentally, it can be seen in Table 8 that there were more decadent than non-decadent plants in all areas investigated. This suggests that the willows are being weakened, possibly by heavy use.

A two by two contingency Chi-square test was performed on the following variables: percentage leader use (L.U.), species of willow (Spp.), age, age class (Age Cl.),

Table 8. Comparison of Decadence and Utilization of Willow

% Leader Use	Decadent %	Non-decadent %
	West Fork	
0	41.0	37.3
5	26.5	30.2
25	15.0	15.9
50	11.7	8.8
70	4.2	5.5
90	1.6	2.3
% of Total Plants	56.6	43.4
	Middle Fork	
0	40.3	46.6
5	22.8	26.1
25	21.4	13.6
50	10.2	8.0
70	4.4	2.3
90	1.0	3.4
% of Total Plants	53.9	46.1
	Ross Fork	
0	49.8	36.1
5	23.4	32.4
25	16.7	11.1
50	8.6	11.1
70	1.0	7.4
90	.5	1.9
% of Total Plants	65.9	34.1
	Total	
0	42.7	39.4
5	25.1	29.5
25	16.7	14.6
50	10.7	8.9
70	3.6	5.1
90	1.2	2.5
% of Total Plants	57.7	42.3

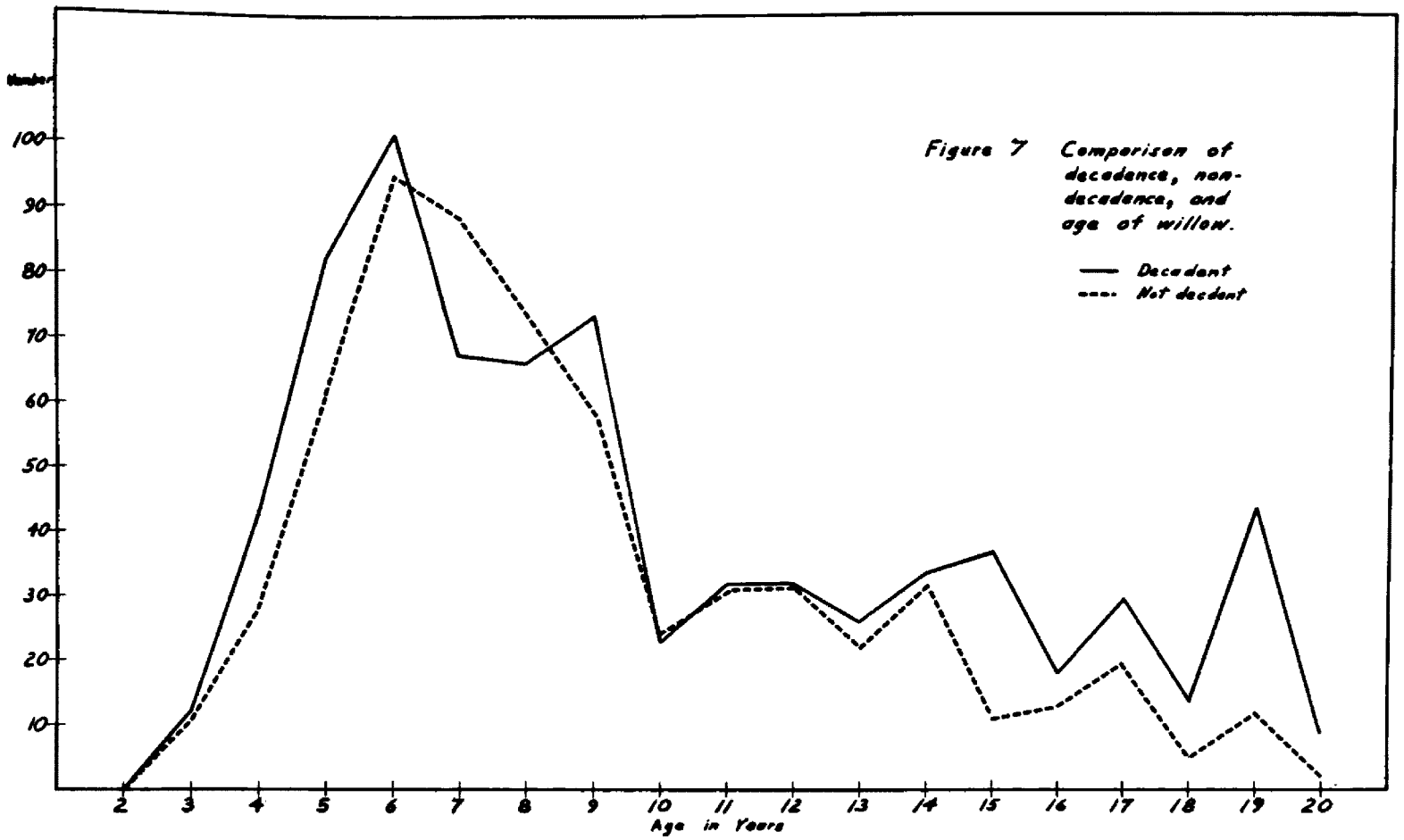


Figure 7 Comparison of decadence, non-decadence, and age of willow.

—— Decadent
---- Not decadent

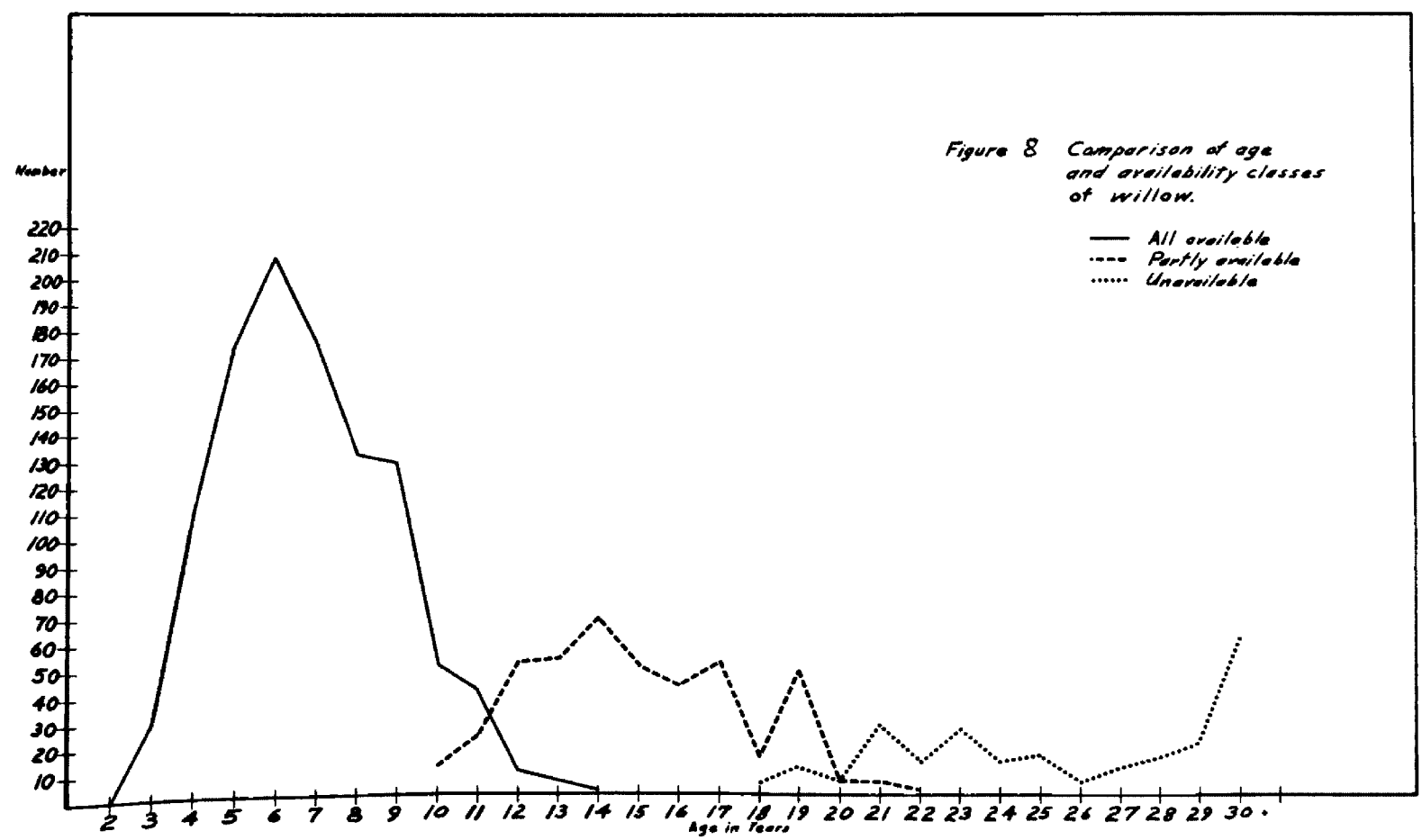


Figure 8 Comparison of age and availability classes of willow.

—— All available
---- Partly available
..... Unavailable

(young, mature, or decadent), form class (F.C.) (availability and past use) and density (dens.). This analysis was performed on forage areas (currently used by moose) and non-forage areas (where there is little or no current use by moose). Table 9 summarizes this analysis. Table 9 shows only two cases of dependency. The first is form class times species in the non-forage area. Form class is a function of leader use and availability. There appears to be a small amount of preference for the species, Salix discolor and S. lemmonii, over S. commutata. (see Table 10)

It is also possible that Salix commutata is a faster growing species or is more tolerant of browsing than the other two and grows into the partly available or unavailable form class more quickly.

The second case of dependency is percentage leader use times density. This is in agreement with the interpreation of the data set forth in Table 6, which compares a density index to utilization in various areas.

Pattern of browsing. It was noticed during the study that the forage areas exhibited a patched, uneven appearance. There were few areas of use that were in large blocks of even-age willow. Most of the forage areas were mosaics of used and unused portions. The areas of relatively heavy use are interrupted by areas of relatively little use. One area which had been burned 8 or 9 years previously was mostly an even-aged stand; on this area there was little browsing.

Table 9.. Chi-Square Test for Variables on Forage and Non-Forage Areas

Area	Dens. x spp.	F.C. x spp.	Age Cl. x spp.	Age x spp.	% L.U. x spp.	F.C. x dens.	Age Cl. x dens.	Age x dens.	% L.U. x dens.
For-age	I	I	I	I	I	I	I	I	D
Non-for-age	I	D	I	I	/	/	/	I	/

I= independent at 95% confidence level
D= dependent at 95% confidence level
/= unable to determine due to zeros in table

Table 10. Utilization of Three Species of Willow by Moose

% Leader Use	Salix discolor		Salix commutata		Salix lemmonii	
	No.	%	No.	%	No.	%
0	265	36.4	312	48.4	128	37.8
5	205	28.2	145	22.5	112	33.0
25	123	16.8	86	13.3	53	15.6
50	77	10.7	65	10.1	36	10.6
70	41	5.6	25	3.9	9	2.7
90	17	2.3	12	1.9	1	0.3
Total	728		645		339	

Observations of feeding moose suggested that there was a decided tendency to feed in areas which had willows high and dense enough to conceal moose from an intruder. Unless the intruder approached too closely, the moose would merely remain motionless and hidden from view. If hiding was not possible the moose would start running for the nearest heavy cover, which was usually coniferous timber. It seems quite likely that willow serves not only as a staple food item but also as cover during the feeding period.

Cover dictated the route by which a moose would enter or leave a forage area. Normally moose would enter or leave a forage area at a point near heavy coniferous cover. Observation of tracks in and out of the willows indicated this to be true. Conversations with the residents of the Ross Fork area revealed that while moose were generally seen entering or leaving the willows at these places in normal winters it was not unusual, during severe winters, to see them much farther away from timber.

Food habits. On the basis of 28 rumen samples collected from September 21 to January 14 and 7,288 "instances of use" obtained by feeding site examinations, the food habits of moose were evaluated on fall, intermediate and winter ranges. Examination of feeding sites was done only on the winter range, which received no use by deer or elk at the time of the study.

Fall. In September, browse plants constituted 69.1 per cent of the plants found in the rumina of four moose. Buckthorn (Rhamnus alnifolia), honeysuckle, huckleberry (Vaccinium sp.), and paper birch (Betula papyrifera) were the major browse plants involved. (see Table 11) It is interesting to note that willow was absent from the samples taken in September. Hosley (1949) states that in September there is a local shift of moose in Montana from the stream bottoms upward to the timbered slopes. If this is the case, there is little willow available in the area which is inhabited by moose at this time. In October, willow, red-osier dogwood, quaking aspen and huckleberry were the most important browse plants. Browse made up 82 per cent of the food taken by moose during this month. Aquatics, grasses and fungi were of minor importance during the fall. Grass-like plants, rushes and sedges, received very little use. Knowlton (1960) found that in the Gravelly Mountains of Montana browse constituted 91.4 per cent of the fall food taken by moose, with willow and alpine fir (Abies lasiocarpa) being the two most important plants. He also found use of forbs to be higher than was noted in the present study. Hosley (1949) states that lodgepole pine is highly palatable to moose. Even though this plant is abundant in the study area it was found only in amounts less than 0.1 per cent. Knowlton (1960) reports no use of lodgepole pine.

Table 11. Analysis of 28 Rumen Samples Collected From September 1948 to January 1960

Forage Plant	Fall Range		Intermediate Range		Winter Range
	Sept. (4)[1]	Oct. (13)	Nov. (4)	Dec. (4)	Jan. (3)
	%	%	%	%	%
Salix spp.	0	23.1	55.7	43.7	80.7
Cornus stolonifera	6.5	17.3	9.7	4.1	0
Vaccinium sp.	10.2	7.4	tr[2]	0	0
Berberis repens	0	4.2	tr	4.8	0
Betula papyrifera	10.2	1.4	0	tr	0
Rhamnus alnifolia	19.2	0	0	0	0
Shepherdia canadensis	0	tr	0	6.8	4.7
Populus tremuloides	0	6.6	0	7.8	2.2
Alnus sp.	0	3.1	tr	1.1	0
Rosa sp.	0	3.2	0	tr	tr
Arctostaphylos uva-ursi	0	tr	0	tr	tr
Acer sp.	0	1.0	0	0	0
Ribes sp.	0	0	1.8	4.9	0
Lonicera sp.	14.0	0	0	0	0
Unident. browse	9.0	15.3	18.5	10.3	8.8
Pinus contorta	tr	tr	tr	tr	0
Pseudotsuga menziesii	0	tr	7.2	12.7	2.3
Unident. conifer	tr	tr	0	0	0
Aquatics	10.0	7.6	tr	tr	0
Grasses	6.1	7.0	1.8	tr	tr
Grass-like plants	2.1	tr	1.6	tr	0
Forbs	1.5	1.0	2.7	tr	tr
Fungus	9.5	tr	0	0	0
Mosses	0	tr	0	0	0
Total browse	69.1	82.6	85.7	83.5	96.4

[1] = sample size
[2] = less than .1 %

Intermediate. On the basis of eight rumen samples collected in November and December it was found that willow was the single most important browse plant. Red-osier dogwood and Douglas fir were also important during this time. Hosley (1949) reports that Douglas fir is highly palatable to moose.

Intermediate range is probably used by moose prior to and directly after the moose are on the winter range. The intermediate range appears to be located on the edge of the winter range and to consist of the adjacent timbered foothills. During the winter the moose do not appear to cross back and forth between the two ranges until the last of March. During the latter part of March the moose begin to forage in the intermediate range. It is not known just how long the moose spend on this range in the spring. Practically all of the red-osier dogwood and quaking aspen plants are heavily used and severely hedged on this range.

Winter. Table 11 shows that willow is the most important browse plant used during January, comprising 80.7 per cent of the total food eaten. On the basis of 1,410 "instances of use" it was found that in January willow constituted 94.9 per cent of the total use in the willow flats. Ninebark and wild rose were of relatively minor importance. Table 12 shows which browse plants were available on the winter range and which were used by moose in January, February and March. During this time all of the species

Table 12. Food Habits in the Willow Flats Expressed as a Per Cent Species Composition Based on 7,288 "Instances of Use"

	Jan. %	Feb. %	March %
Salix spp.	94.9	89.9	76.5
Physocarpus sp.	2.9	2.2	1.3
Pseudotsuga menziesii	0	1.4	.3
Rosa spp.	.8	3.6	1.6
Lonicera spp.	1.3	1.8	1.7
Cornus stolonifera	0	0	16.0
Betula fontinalis	0	1.0	2.0
Pinus contorta	Trace[1]	3.8	.6
Shepherdia canadensis	0	Trace	0

[1]= less than .1 per cent

listed were available to the moose except red-osier dogwood which is found only at the upper edge of the winter range. As soon as the moose began to use the upper portion of the study area, in March, use on red-osier dogwood became appreciable. This species appears to be a favorite food of moose, a conclusion also supported by the observations of Harry (1957) and Knowlton (1960).

Decadence and age. Decadence is the presence of dead or almost-dead wood; a decadent shrub is one in which twenty-five per cent or more of the crown is dead (Dasmann, 1951). Within the ages of plants that at were at least partly available (Fig. 7) there seems to be little difference in the amount of decadence until the plant is about 15 years old. After that age more plants are decadent than non-decadent. Utilization of plants over 15 years old is not very high. Plants over 20 years old are predominantly decadent and, of course, are receiving practically no browsing. It would appear that decadence of plants over 20 years old is due to age and not utilization. Plants from 15 to 20 years old which are decadent and have received relatively heavy use might illustrate that age coupled with some degree of use increases decadence in individuals of this age group. Plants less than 15 years old receive the heaviest use and decadence in these plants is probably due mainly to browsing.

Age and availability. Availability of the observed plants was determined by assignment to form classes after

Cole (1958). When availability is charted against age the availability picture becomes clear.(Fig. 8) The first time that a willow shoot becomes available to moose is when it is 3 years old; prior to this time snow usually covers the young plant or shoot. From 3 to 11 years the greatest majority of the plants are within the "all available" range. Willow plants or shoots ranging from 12 to 20 years old are in the "partly available" class. Of 182 plants over 20 years old, none were "all available," eight were "partly available" and 174 (96 per cent) were "unavailable."

DISCUSSION

Moose observations. The Schnabel method of population estimates and the observational estimate resulted in closely similar population estimates. The mild winter probably had some influence on the number of moose using the study area. Some moose may not have come down to the willow flats which were under observation and therefore only a portion of the total population in the upper Rock Creek area may have been available for study. Observations of moose several miles from the willow bottoms indicate that this might be the case.

Calves appeared in the largest number in the collection of jaws but this is believed to be due to a differential vulnerability factor. The small sample sizes involved in this study do not warrant drawing any conclusions about age class dominance.

Range appraisal. While it appears that decadence has little effect on utilization, the data (Table 8) indicate that utilization has an effect on decadence. Over-use of a plant decreases its vigor and, if continued, results in the death of the plant (Sampson, 1952). If a plant receives over-use for a shorter period of time a portion of the plant dies and if utilization diminishes the plant will regain

its vigor, continuing to produce forage. In Fig. 7 one can see that in the younger age groups, the number of decadent and non-decadent plants are approximately equal. Decadence in this age group is probably due to some environmental condition, which may be over-use. Petersen (1955) reports that proper use for willow varies from 15 to 75 per cent, depending upon species, soil, moisture, etc.

It is possible that there is another factor which influences decadence besides utilization and age. A great proportion of the plants in the study area are resprouts and since age of the root crown is unknown it might be possible that the root systems are so old that they are incapable of carrying on metabolic activity capable of sustaining the plant in a healthy condition. In Poland, where willows are planted and harvested for baskets, the root stalks must be replaced every ten years to maintain economic production (Taber, 1960). Westveld (1939) mentions that good sprouts from cottonwood can be expected only when the trees are thirty years of age or younger. He also says that no sprouting was found when the plants were over 45 years old.

In the study area results of increment boring revealed that some of the willows were over 50 years old and aerial photographs taken in 1937 showed that there has been no major change in the willow dominated areas. This indicates that some of the root crowns could be from 25 to 50 years old. If this were the case, decademce of younger plants

(resprouts) might be attributed to senility of root systems. Senescence of root crowns is mentioned to point out what the possibilities are and to indicate what further studies should be carried on in order to understand more fully the inter-relationships between willow and moose. A study which would evaluate the "resprouting potential" of known-age willow would be an important contribution.

The characteristic groupings of availability classes has an important bearing on the management of willow habitat for moose. Unless a good proportion of the willow stand is composed of younger plants or resprouts, forage production will not be optimum for moose.

It appears that moose prefer to feed in areas that have sufficient cover nearby. Observation of 361 sets of tracks entering the willows showed that only one set entered the edge of the willows at a point over 100 yards from coniferous cover. Places of heaviest moose traffic entering and leaving the willows were those which had coniferous cover next to the willows. The forage areas were characterized by numerous young plants or resprouts interspersed with older willows, resembling an uneven checkerboard. The individual openings containing the more heavily used willow were often as small as 50 yards wide. It is quite probable that the amount of "edge" influences what the moose will use on willow winter range.

At present, winter range size and condition do not appear to be limiting the moose population. There are several areas which appear to be capable of supporting moose that are receiving little use.

It is possible that the intermediate range is the limiting factor or at least one of several factors which limit the moose population of this area. Red-osier dogwood, which is very palatable and the browse plant offering the bulk of the forage on the intermediate range is very heavily used and appears to be dying out. A study which would determine the extent, forage production, number of moose and the time they spend on the intermediate range is necessary for a full evaluation of the factors limiting moose in this area.

In the event of increased logging operations in the area it is possible that the productivity of the intermediate range would increase due to the opening of the canopy and the subsequent establishment and release of palatable browse species. Due to the apparent preference by moose for forage areas with convenient escape cover, large clear-cut logging operations would probably be less favorable than smaller blocks of clearings.

SUMMARY

In the early part of the 1900's there were few Shiras moose in the Rock Creek area. Since that time the moose have gradually increased and by 1940 they were common enough to be seen frequently by fishermen and hunters using the area. Moose have been harvested in the area on a permit basis since 1947. The harvest reached a peak of 36 animals in 1955.

Since the mid-1800's livestock grazing has been important in the area. Presently the bulk of the privately owned land is utilized as pasture. Logging in the area is limited but appears to be increasing. Douglas fir and lodgepole pine constitute the bulk of the timber cut.

Moose hunters were requested to collect various biological specimens for the study. Twenty-six rumen samples which they collected were analyzed. Willow was found to be the most important browse plant used during the fall and winter. Grass, aquatic plants and fungi were of minor importance. Browse plants constituted from 69.1 % to 96.4 % of the total food eaten by moose. Red-osier dogwood is very palatable and is of importance in this area in the fall and early spring. During the winter of 1960 observations of moose and moose tracks were recorded in relation to location,

sex, age and weather conditions. Willows were sampled in 13 different areas. The selected willows were tabulated as to age, density, availability, species, decadence and utilization. Feeding site examinations were made in various locations in the willow flats.

The population of moose using the willow flats of the area was estimated to be from 26 to 28 moose. Data collected from two fall hunting seasons, one summer and one winter, revealed a population composition of 43 % females, 42 % males and 15 % calves. Twenty jawbones collected indicated a high proportion of young animals in the kill, but it is not known if this reflects true age class composition.

The most intensive use of the willow flats by moose during the study commenced about the first of January and lasted about two and one-half months. The depth of snow in the willow flats at this time of the year did not hamper the movement of moose.

The peak of daily activity was thought to be at about daylight and activity of moose during stormy weather was limited.

The use on willows which were from 4 to 9 years old and 2 to 7 feet tall was proportionally greater than on other age and height groups. This age group made up the largest of the age classes present. Utilization of decadent and non-decadent plants by moose was similar. At 15 years, the age of willow appears to influence decadence and over 20 years,

decadence is probably due to age alone. Willows from 3 to 11 years are "all available", from 12 to 20 years are "partly available" and over 20 years are "unavailable". Willows from 0 to 3 years old are covered by snow during the winter but receive some use by the few moose that are year-around residents of the willow flats.

The most favorable winter forage areas for moose are those which have: an uneven plant age composition, closely spaced willows and coniferous cover nearby. Prior to and after the time the moose are on the winter range they appear to utilize an intermediate range which is characterized by slightly higher elevations and coniferous timber with red-osier dogwood the most important browse species. The importance of the intermediate range in the ecology of moose is not fully understood but is thought to be a possible limiting factor. Logging on a block cutting basis would possibly enhance the intermediate range for moose.

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